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ALMA Operations and the European ALMA Regional Centre

interaction with and support to the users

Paola Andreani

ALMA Early Science, IRAM Grenoble 29/11-1/12 2010

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Meaning of ALMA Operations and the Joint ALMA Observatory

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Science Operations Astronomer's perspective

Principles:

- Non-experts should be able to use ALMA
- Dynamic scheduler to match observing conditions
- Reliable and consistent calibration
- Data public in timely fashion

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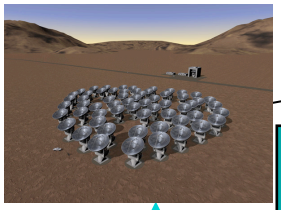
ALMA Operations Sites in Chile



Antenna Operations Site (AOS)

60 MB/s (peak)

6 MB/s (average)

Operation Support Facility (OSF)

Santiago Central Office (SCO)

array scheduling + operations
quick-look, maintenance and repair

issues of calls
PRC process
SB checks
pipeline data reduction
quality assessment
Population of the archive

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High-level concepts for Science Operations

- Observations only in service observing mode with flexible (dynamic) scheduling.
- Observations 24h/day interrupted by maintenance periods.
- All observations executed in the form of scheduling blocks (SBs).
- Default output: reliable images, calibrated according to the calibration plan.
- The Joint ALMA Observatory (JAO) is responsible for the data product quality.
- All science and calibration raw data are captured and archived.

as in the ALMA Operations Plan

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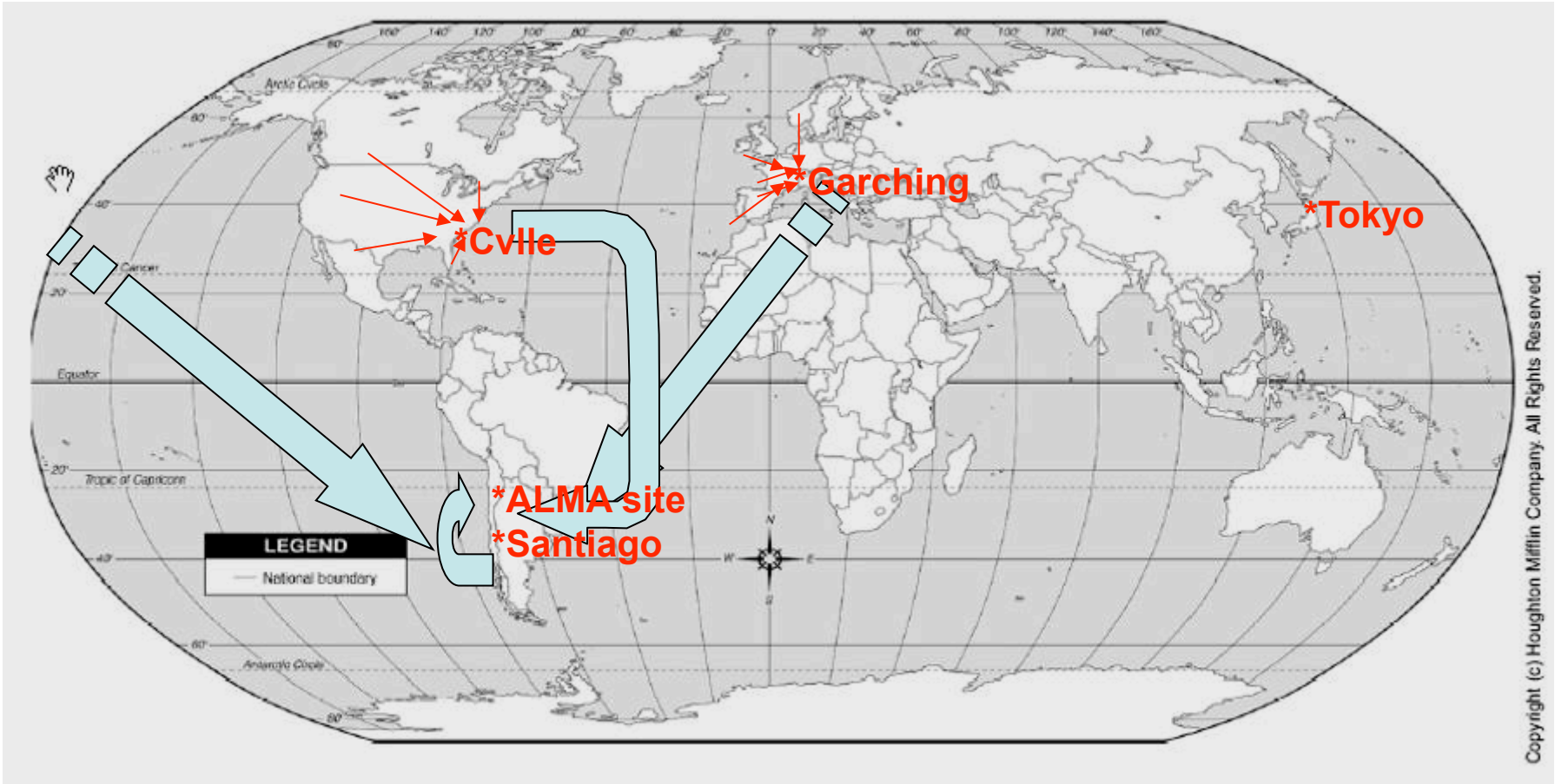
ALMA Science Operations sites
OSF, Santiago and the ARCs



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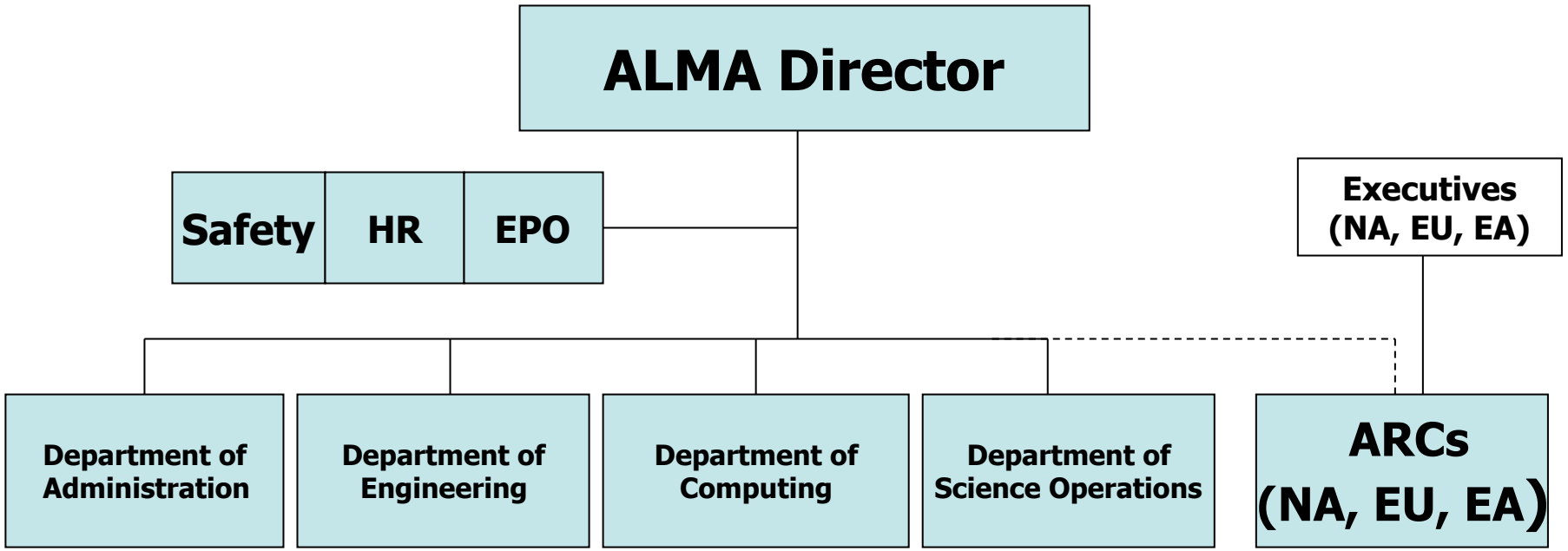
Joint ALMA Observatory (JAO)

- ALMA is operated by the JAO.
- The ALMA Regional Centres (ARCs) form an integral part of JAO operations.



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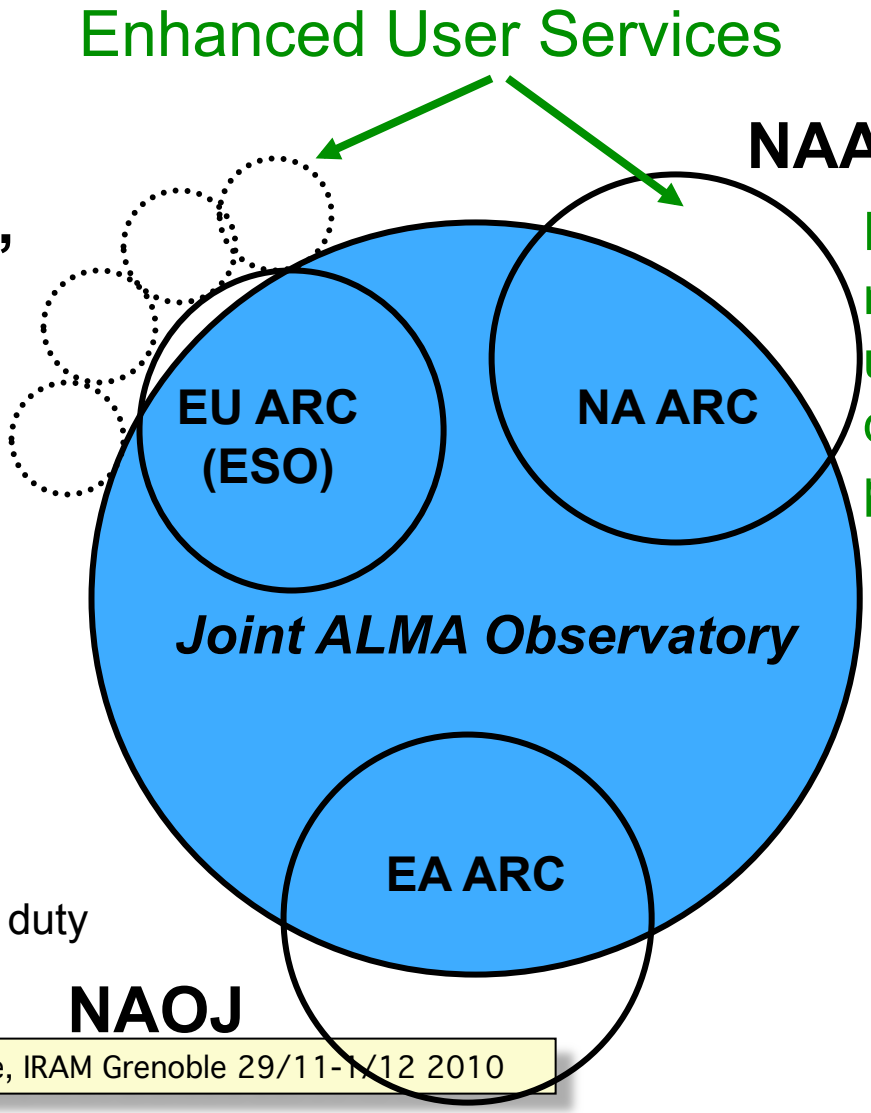
The Regional centres

ALMA Operations: Three ALMA Regional Centres - ARCs



Enhanced services are needed to provide advanced user support, algorithm development, student programs, EPO, grants

ARCs provide
user interface,
archive,
software tools
data delivery

Astronomers on duty

DSO provides:
- Array operations
- Scheduling of projects
- Execution of observations
- Data quality assurance and trend analysis
- Calibration plan maintenance
- Delivery of data to the archives
- Archive operations
- Pipeline operations

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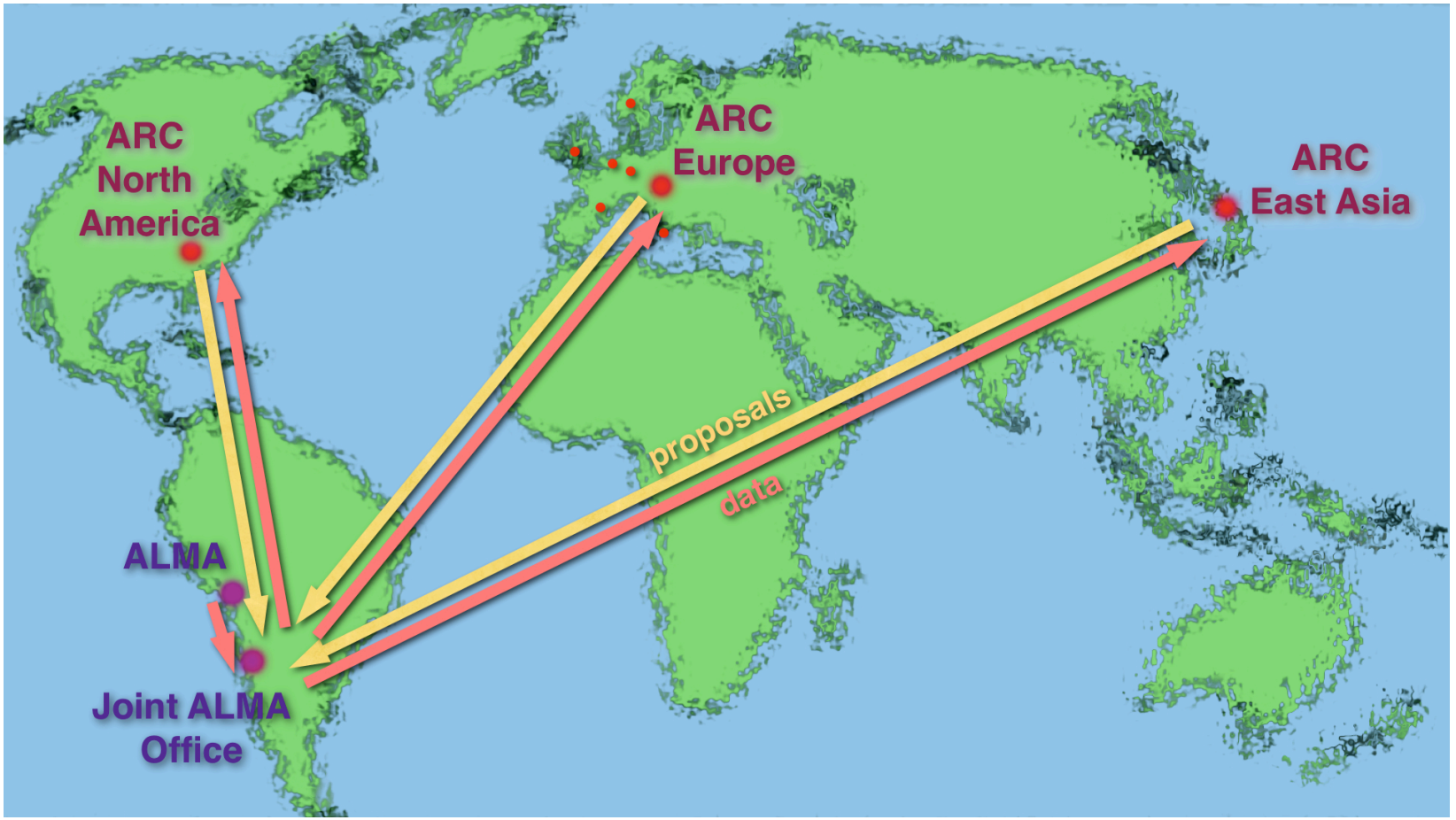
The ARCs and their relation to the JAO



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Work flow of ALMA Operations

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Getting ALMA time

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The User Portal: single sign-on

Access to helpdesk, data archive and project tracker

- Home
- Science Archive
- XML Store
- Bulk Store
- Monitor/Logging Store
- News
- Events
- Users
- Services
- Archive admin
- Documentation
- Proposal handling
- Project Tracker
- Assessor tool
- ARP meeting tool
- APRC meeting tool
- Meeting tool
- Helpdesk

Info Welcome! You are now logged in.

Welcome to the ALMA Science Archive

ALMA Science Archive Front Page

Overview

The ALMA Science Archive (ASA) provides access to all data obtained by the ALMA observatory, both from the main array and the ALMA Compact Array (ACA). This includes data and data descriptions (meta-data) collected throughout the execution of ALMA observing projects like

- Observation project descriptions including abstracts.
- Technical data about the array, receiver and correlator configuration.
- Scheduling information and project status.
- Ambient conditions.
- Science and calibration data from the correlators (raw visibilities).
- Quick-look data.
- Reduced image stacks.

Depending on availability, added value products are also made available or linked to the observational data. Access is provided through web query forms and through interfaces following the standards as defined by the International Virtual Observatory Alliance (IVOA).

Data Availability

In general all data is publicly and freely available after a proprietary period of one year. All calibration data is available immediately after final ingestion into the ASA. Basic access and browsing is possible without registration, the more advanced features of the ASA and data retrieval requires prior registrations and authentication.

Current Status

Since ALMA is not yet operational most of the interfaces and data are not yet available to the general public and only registered users are able to

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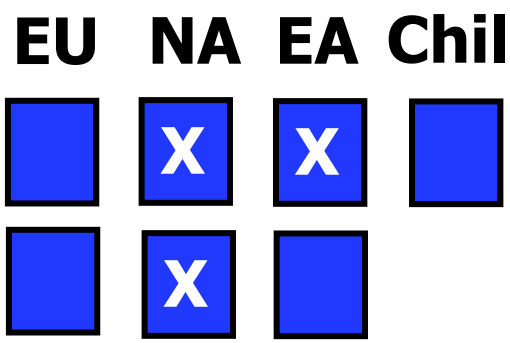
Observers' affiliation identified in User Portal profile

- Eligible Affiliations
- Preferred ARC for support



(checkbox; i.e. multiple selections allowed)

(radio button; i.e. only single selection allowed)

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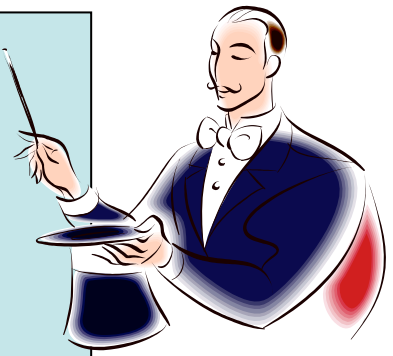
Getting ALMA time

Phase I

- **Joint ALMA Observatory issues calls for proposals**
  - Reg
  - Prep
  - user
    - ➢
  - **A**
    coo
    - ➢ Program Review Committee ranks proposals
- **Executives approval**

MAKE A PROPOSAL!

Scientific case
Instrument setup: **frequency**
rms
S/N
source extension
spatial resolution



ALMA sensitivity calculator

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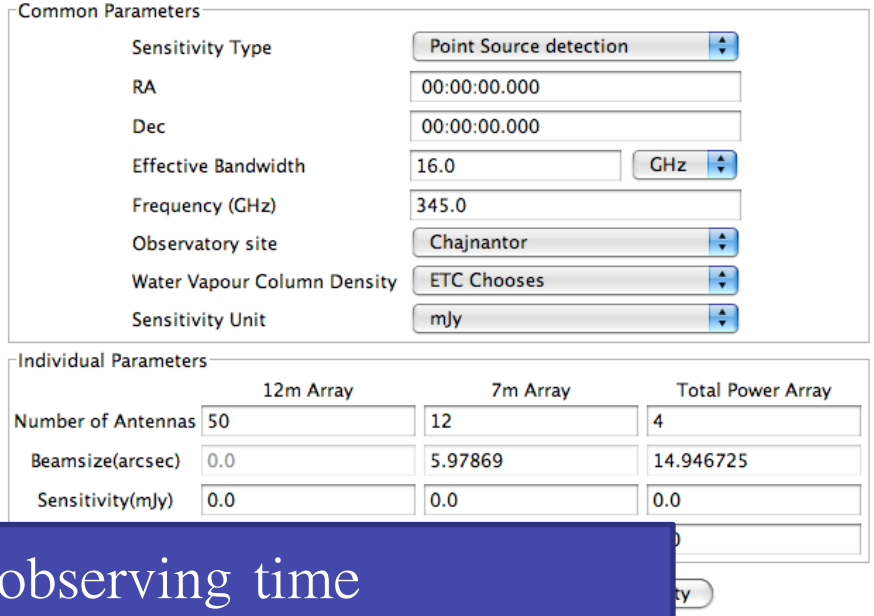
ALMA Sensitivity Calculator

This tool will calculate the necessary integration times for a given sensitivity, or vice versa, for your ALMA observing project. Input and output parameters are explained below. You can also get additional information on the valid range for each parameter by hovering your mouse pointer over each field in the calculator applet.

To run the calculator you need the Java Plug-in installed. If you do not see the calculator then it is likely that you do not have it installed. Instructions for installing the plugin will vary depending on your browser and operating system. A plugin compatible with the Java Development Kit version 1.6 (or Java6) is recommended (version 1.5 should work at the moment). Please contact your IT department for installation help if necessary.



Estimate observing time
Customize number of antennas
Vary conditions

Parameters

Common Parameters

- **Sensitivity Type:** Choose between a point-like or extended source.
- **RA/Dec:** Coordinates of the observation target.
- **Effective Bandwidth:** The standard observing mode will be using two polarizations. Therefore, for continuum observations with 8GHz bandwidth an effective bandwidth of 16GHz needs to be selected. For line observations, use double the spectral resolution element width.
- **Frequency:** Observing frequency. This must be within the boundaries of ALMA bands 1 to 10, which are as follows:
  - Band 1: 31 GHz - 45 GHz
  - Band 2: 67 GHz - 90 GHz
  - Band 3: 84 GHz - 116 GHz
  - Band 4: 125 GHz - 163 GHz
  - Band 5: 163 GHz - 211 GHz
  - Band 6: 211 GHz - 275 GHz
  - Band 7: 275 GHz - 373 GHz
  - Band 8: 385 GHz - 500 GHz
  - Band 9: 602 GHz - 720 GHz
  - Band 10: 787 GHz - 950 GHz
- **Observatory Site:** For ALMA observations, leave this as Chajnantor.
- **Water Vapour Column Density:** "ETC Chooses" will select an appropriate value according to the input frequency.
- **Sensitivity Unit:** This will change automatically according to your choice in the "Sensitivity Type" field.

Individual Parameters

- **Number of Antennas:** 50 for entire main array, but in practice the entire array need not be used and subsets of the main array may work independently.
- **Beamsize:** Desired angular resolution, or FWHM of the synthesized beam. Only editable for extended source observations.
- **Sensitivity/Exposure Time:** Noise level and telescope integration time. Input one to calculate the other.

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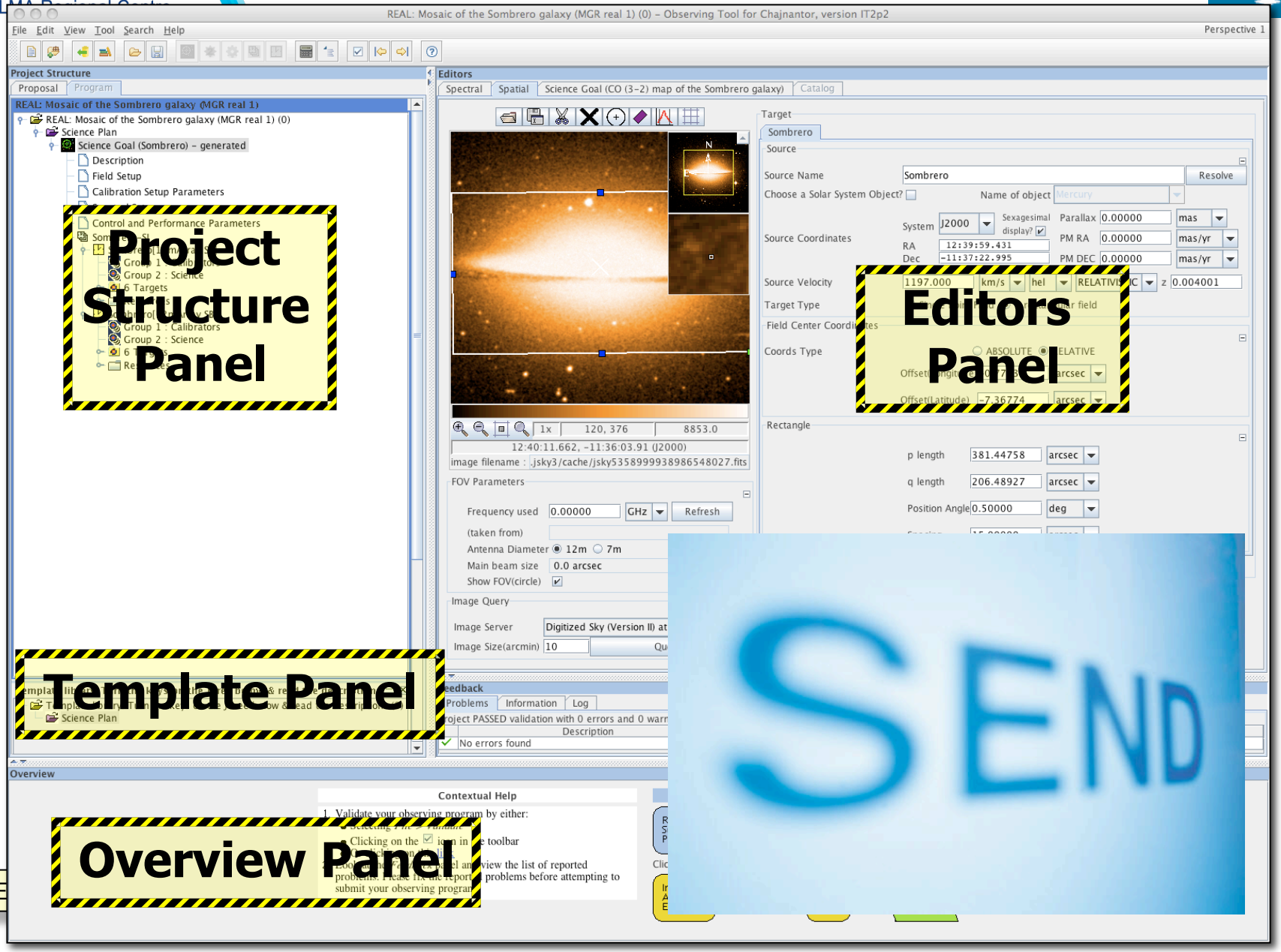
The ALMA observing tool



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Getting ALMA time

Phase II

- Phase I: Proposals are submitted using ALMA Observing Tool
  - **Phase II:** Successful PIs submit observing programme using the Observing Tool
  - Preparation of the scheduling blocks
  - European ARC helps with observation planning and validates observing schedule

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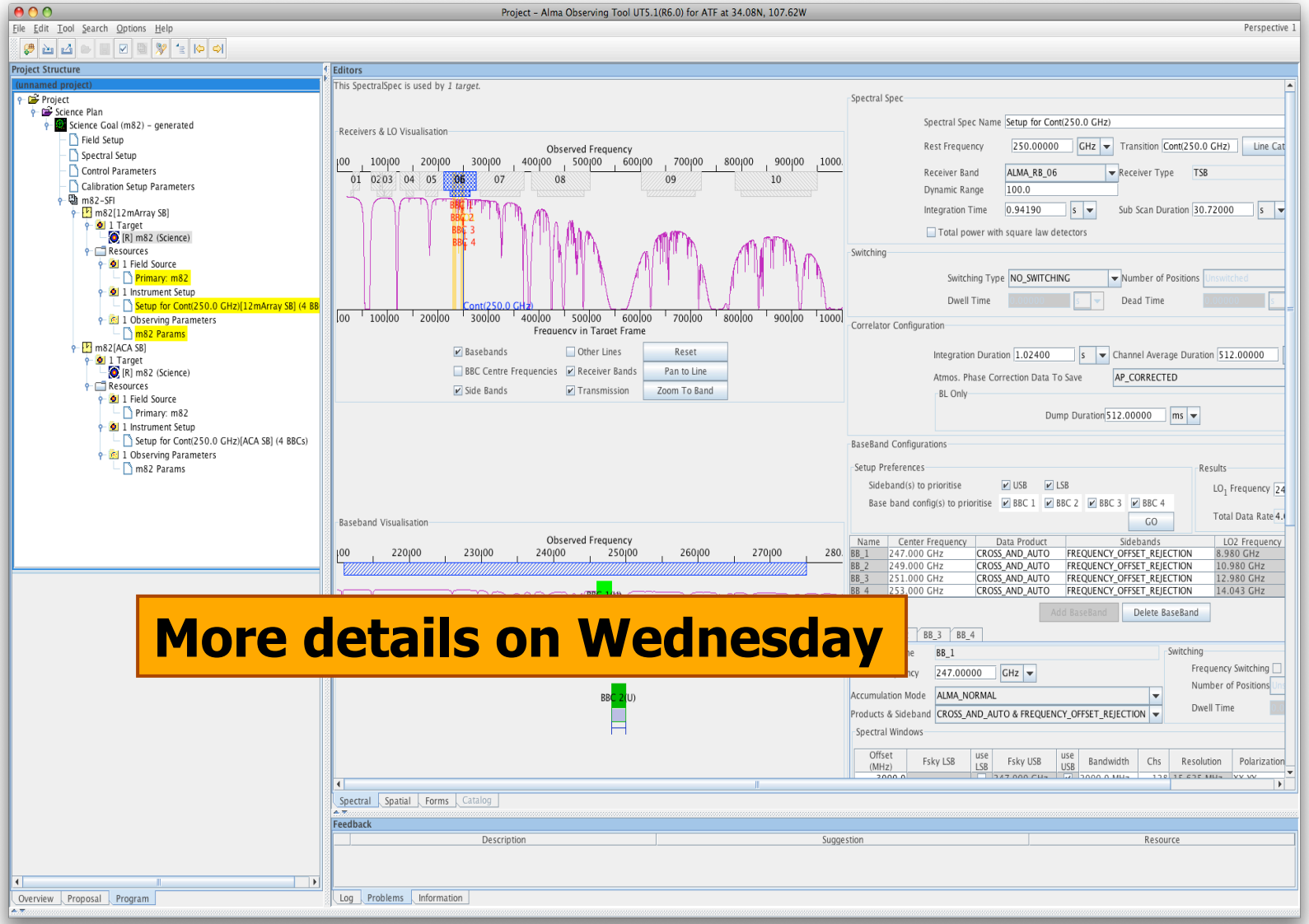
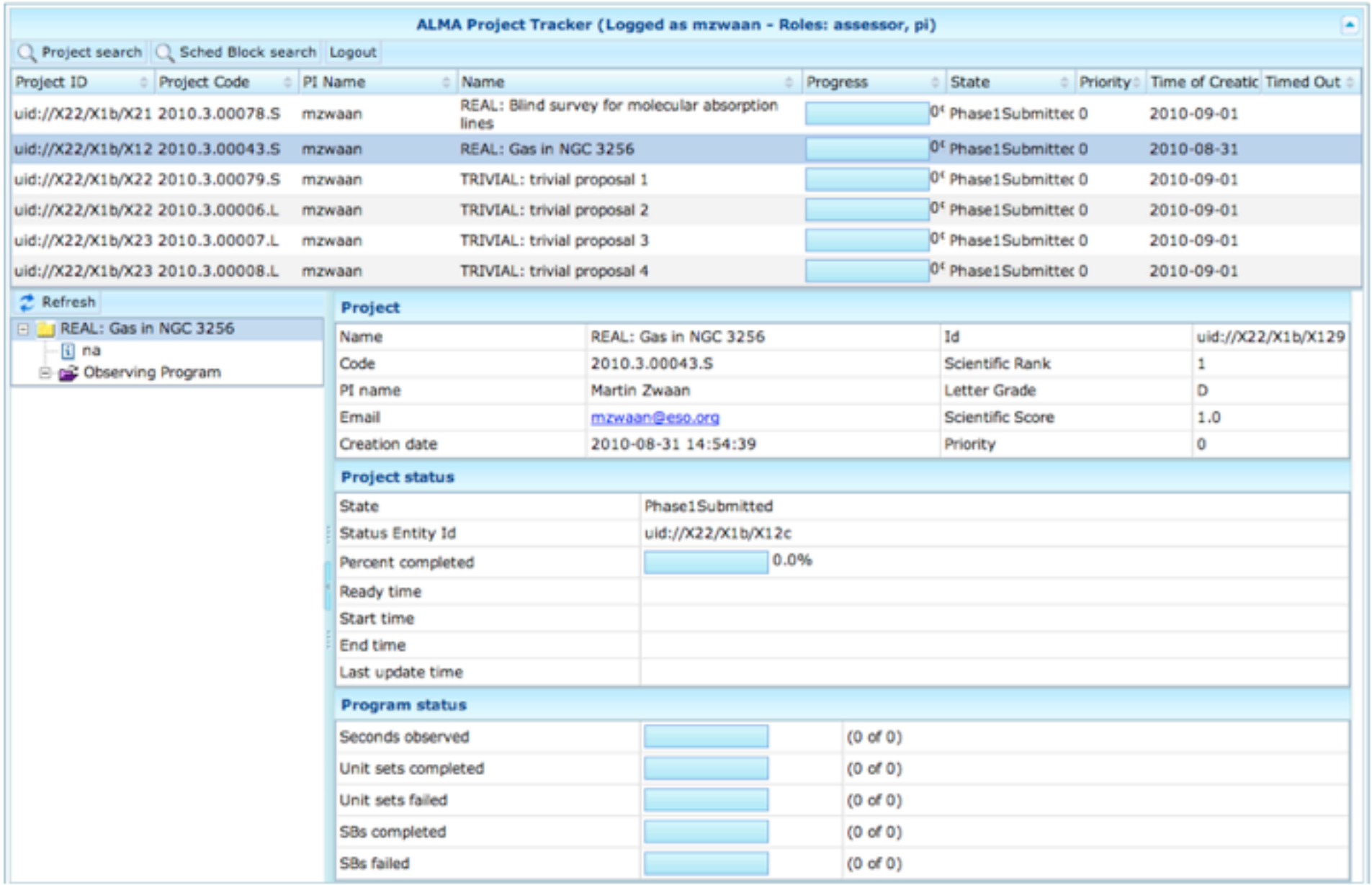
The ALMA observing tool

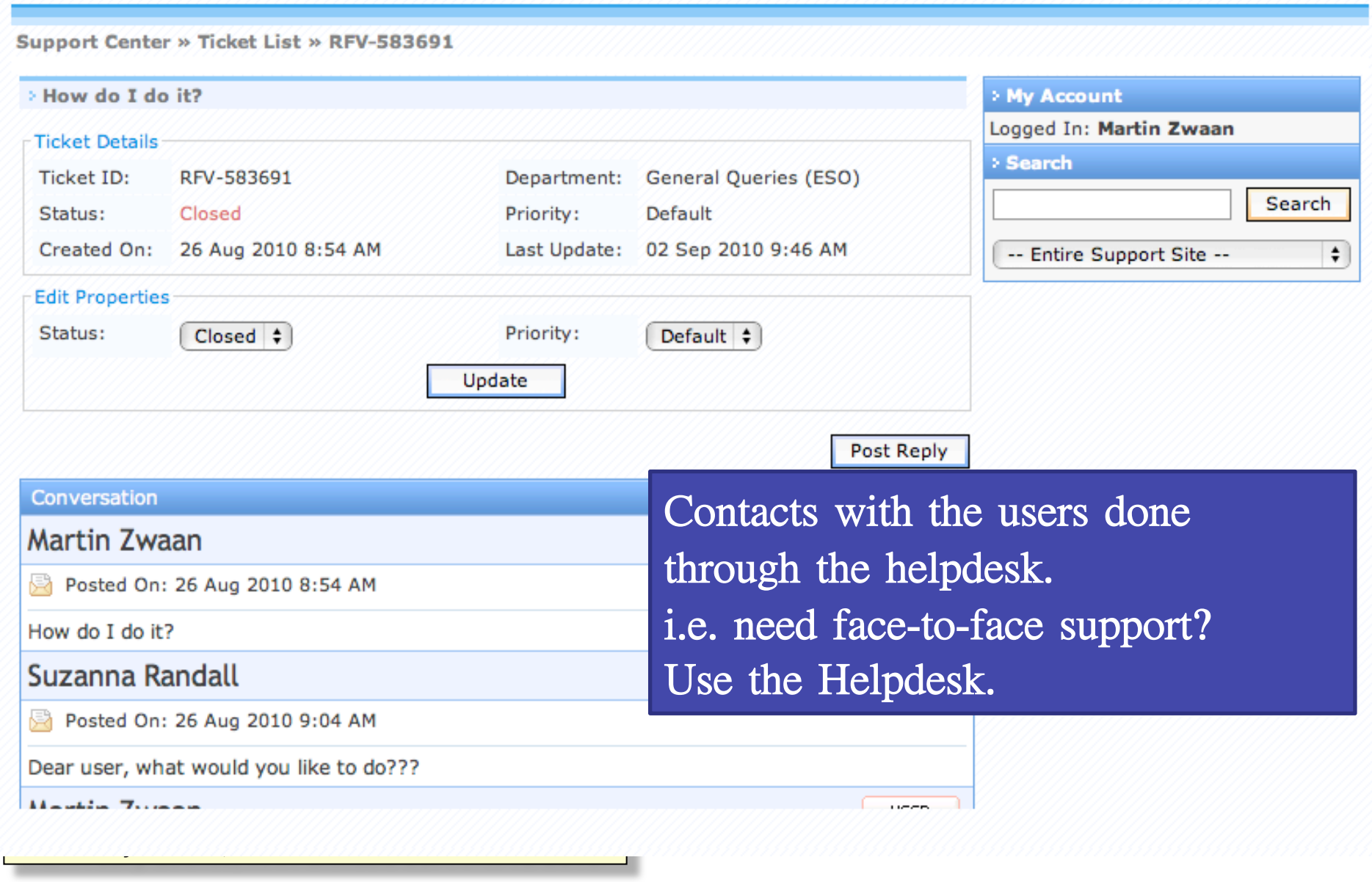


More details on Wednesday

The **Project Tracker**



The helpdesk



Contacts with the users done through the helpdesk.
i.e. need face-to-face support?
Use the Helpdesk.

ALMA DATA FLOW

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PS Phase 1

Technical feasibility

PRC

JAO

Medium Term Queue

Long Term Queue

JAO

ARCs

PS Phase 2

Project

Scheduling Blocks

Archive

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Assessing data quality

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Assessing Data Quality (Quality Assurance)

- Objective: Assess impact of ill-effects during data taking and reduction. Accept if impact is within specified ranges for all parameters.
- Assumption: Quality of data can be described by sets of single parameters. Joint effects of these parameters are second-order effects.
- ALMA Approach: Breakdown of QA into broad steps that mimic data flow.
  - Data Taking:QA0 (SB-level) & QA1 (Observatory Tasks)
  - Data Reduction:QA2 (Science Pipeline)
  - Post Data Reduction:QA3 (Feedback from users)

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Assessing Data Quality (Q0)

- Deals with rapidly-varying calibration/quality parameters that have to be measured within the Science SBs (or sequences of SBs)
- Done by AoDs in semi-real time
- Based on QuickLook outputs, both displays/alarms and the Calibration Summary files.
- At the end of an SB or a sequence of SB repeats, the AoD will assess QA0 and decide whether the SBs are satisfactory. If so, it will force a state transition in Project Tracker from “Suspended” to “Fully Observed”. The AoD will also make a comment (in Project Tracker) to justify this, or make other comments.
- Otherwise, it is set to “Broken” and from there it can be reinstated into the queue for re-observing

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Assessing Data Quality (Q0)

Parameter Name	Subsystem	Notes	Acceptable Ranges
Weather Parameters (T, P, %RH, Wi	M&C	Used by ATM model. Usable together with Tsys.	Meaningful numbers
Sky Opacity	TelCal/QL	Derived with Dual-Load ATMCals (atmospheric cals) and with Skydips	<20% previous measurement (cor
System Temperature	TelCal/QL	Derived with Dual-Load ATMCals (atmospheric cals)	<20% previous measurement
Phase Fluctuations	TelCal/QL	Derived from observations of calibrators using FSW	<1.5 times previous measurement
		May be done at different freq from target observations.WVR data also available.	
Total Power levels & fluctuations	M&C, TelCal/QL	Check power levels and fluctuations regularly. Use info to compare with weat	<1.2 times previous measurement
Antenna Gain	TelCal/QL	Computed during Amplitude Cals if flux of calibrator known	0.8-1.2 times previous measureme
Antenna Tracking	M&C, TelCal/QL	Evaluated at any time during tracking by comparing encoder and commande	<relative pointing spec (0.6")
Relative Pointing	TelCal/QL	TBD frequency, usually with calibrators within a few (2-3degs) from target	<1/10 HPBW, or 0.6 arcsec, which
Focus	TelCal/QL	Separate measure per axis or Coma optimization. Antenna includes model fc	<λ/6 (axial), lateral based on coma
Delay Measurements	TelCal/QL	Little variation expected if hardware is stable enough	<0.01nS from nominal value for ea
RF Bandpass (Amplitude and Phase)	TelCal/QL	Using bright flat-spectrum calibrator. Amplitude cals can also provide tests fo	<8dB peak-to-peakrange over 1.87
Receiver Temperature	TelCal/QL	Measured during ATMCals (atmospheric Cal). Significant increases can mea	<20% deviations from previous me
Receiver SideBand Ratio	TelCal/QL	Needed for all RXs (2SB and DSB). Once per tuning should be enough.	2SB <1/10, DSB ~20% from 1/2
ACA Issues	M&C, TelCal/QL	Nutator, WVRs and Shadowing	

The parameters can be grouped into the following categories:
Atmospheric Effects: Weather Parameters, Sky Opacity, System Temperature, Phase Fluctuations, Total Power Levels, WVR Outputs.
Antenna Issues: Antenna gain, Relative/Offset Pointing, Focus, Antenna Tracking, Geometric Shadowing, Nutators.
Front-End Issues: RF bandpass, Sideband Ratios, Receiver Temperatures, LO lock status.
Connectivity Issues: Total Power levels, Delay Measurements, System Temperatures, RF Bandpass, LO lock status.
Back-End Issues: Total Power levels, RF Bandpass, Delay Measurements.

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Assessing Data Quality (Q1)

Deals with slowly varying parameters (>1 week) of the performance of the array that will be tackled by semi-periodic "Observatory Task" observations.

- Measured by AoDs
- Based on different reduction packages at this point but expected to converge to TelCal and CASA tasks

Parameter Name	Subsystem	Notes
Delay Measurements	Telcal	Relative delays between basebands,Polarizations, etc
Pointing Model Determination	Telcal/QL/TPOINT	All-sky pointing. Interferometric is the only way to get 2arcsec rms
Focus Model	Telcal/QL	Focus per receiver band as a function of elevation and ambient temperature
Antenna Location Determination	Telcal/CASA	Measured at Band 3 (more calibrators available). Done whenever an antenna is moved/re-i
Signal Path delay determination	Telcal/CASA	Approximate value from pad positions + cable length to correlator
Primary Beam determination	Offline/CLIC	Beam/Sidelobe shape in Amplitude and phase using celestial holography. Also surface larg
Optics (Alignment: Surface setting,subref position, receiver feeds, beam sc	Offline	Needed whenever FE is changed/upgraded and/or surface reset
Antenna Gain-El Curve	Offline	Input to Pipeline for beam cleaning, correction of beam effects, etc.
ACA Issues	Telcal/QL	Calibration issues, different types of antennas, WVR phase correction, etc
Polarisation		Measure Instrumental Polarisation, cross-terms

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Assessing Data Quality (Q2)

- Issues detected during the data reduction process and in the final product (image datacube)
- mainly issues of consistency of calibrations within a given set of SB repeats, and sets observed with different arrays and/or configurations
- done with CASA scripts that will measure the parameters on the final products and (AQUA tool) searches of the logs output by the Science Pipeline

- Some of the parameters are more abstract and will be evaluated with a mixture of metrics (example, Imaging Quality)
- Will be done at the SCO by PMG & DMG Astronomers and Fellows/Data Analysts

Parameter Name	Subsystem	Notes(Goals)	Acceptable Ranges	Frequency of Measurements
Amplitude Calibration		Consistency for all datasets (Relative and Absolu	Relative: 1-3%, Absolute: 5%	**SB_MULT** (Relative), **SB_SING**(Absolute)
Bandpass Calibration		Corrections acceptable for Science Goal	Goal of Project (1/100, 1/1000)	**SB_SING** (once per tuning)
Gain Calibration		Complex gain corrections adequate		
Antenna Gain (Absolute)		Consistent Antenna Gain Calibrations	<3σ of mean value per SB	**SB_MULT** (Once Per Amplitude Calibration)
Bad Data Flagging		Flags set correctly		**SB_MULT** (may be needed several times within S
Polarization		D-term stability, Paralactic angle consistency	~0.1% in Polarization	
Phase Correction		Short and long term corrections adequate	~10x(1+PWV(mm)) μm (freq. de	**SB_MULT** (Fast Switching + WVR)
Image Fidelity Parameters		Image Quality Parameters ALL check!		**RESULT** on merged data

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Assessing Data Quality (Q3)

Issues missed by all the other QA assessments
•represent deeper problems not been detected in tests of some specific observing modes, set-ups, etc
QA3 is all-encompassing, but most of calibration and processing problems should be picked up at QA2
•PIs will report the problems to their ARCs for evaluation
•If a problem is present, the ARCs will report the problem to DSO for resolution
•Depending on the steps required for resolution, it may require re-reduction of some of the data

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Getting ALMA data

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Getting ALMA data

- Queue based dynamic scheduling
  - Programs are composed of 30-60 min scheduling blocks
- Raw data pass through multi-tiered quality assurance
  - Combination of on-site duty astronomer, ARC staff, and automated checks
- Data proceeds to pipeline and archiving
  - Data available from ARC (ESO) maximum within ~2 weeks (quicker for small programmes)
  - Pipeline products (images and calibrated u-v data), raw data, off-line data processing software made available to PIs
  - Expert hands-on data reduction help from ARC nodes staff provided on request, helpdesk always available

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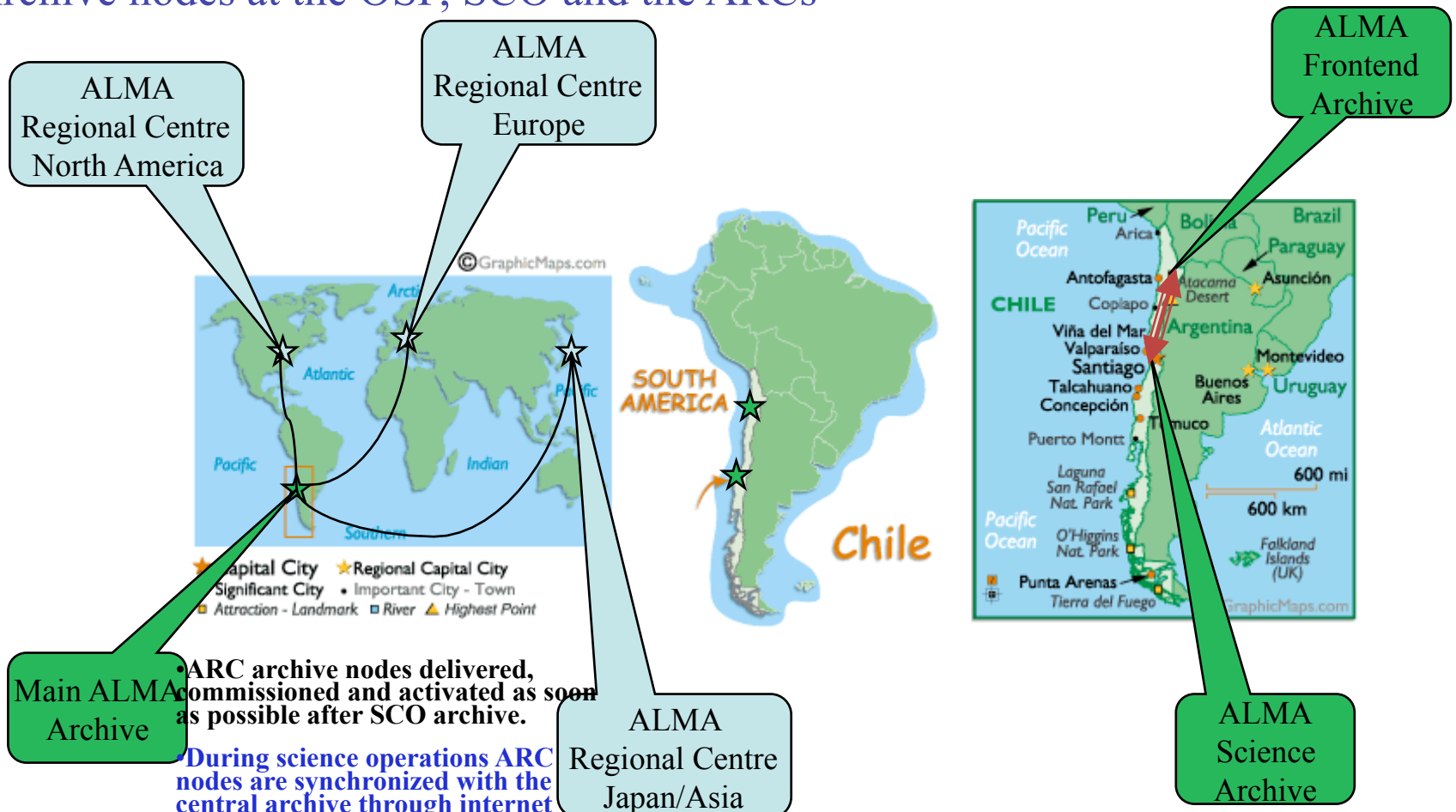
The ALMA archives and data distribution

Archive nodes at the OSF, SCO and the ARCs



- **ARC archive nodes delivered, commissioned and activated as soon as possible after SCO archive.**
- **During science operations ARC nodes are synchronized with the central archive through internet (small data sets) or via physical media.**

OSF connected to SCO via high-bandwidth. It MUST be always possible to operate ALMA even if the internet link does not work

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Data Available for download and/or on media

- Available data:
  - Raw UV visibilities
  - Calibration & flagging tables
  - Casapy reduction scripts
  - Imaging products (calibrated cubes & reference images)
    - Source visibilities with calibration & flagging applied

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Data reduction

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Offline Data Processing

- Download CASA & CASA documentation/guides/use cases
  - Interface: JAO & ARC webs
  - Actors: JAO & ARCs, assembling & posting material
- Attend CASA tutorial
  - Interface & Actors: ARCs, including nodes
- Ask questions
  - Interface: helpdesk
  - Actor: ARCs
- Visit an ARC node for face-to-face support
  - Interface & Actors: ARCs, including nodes

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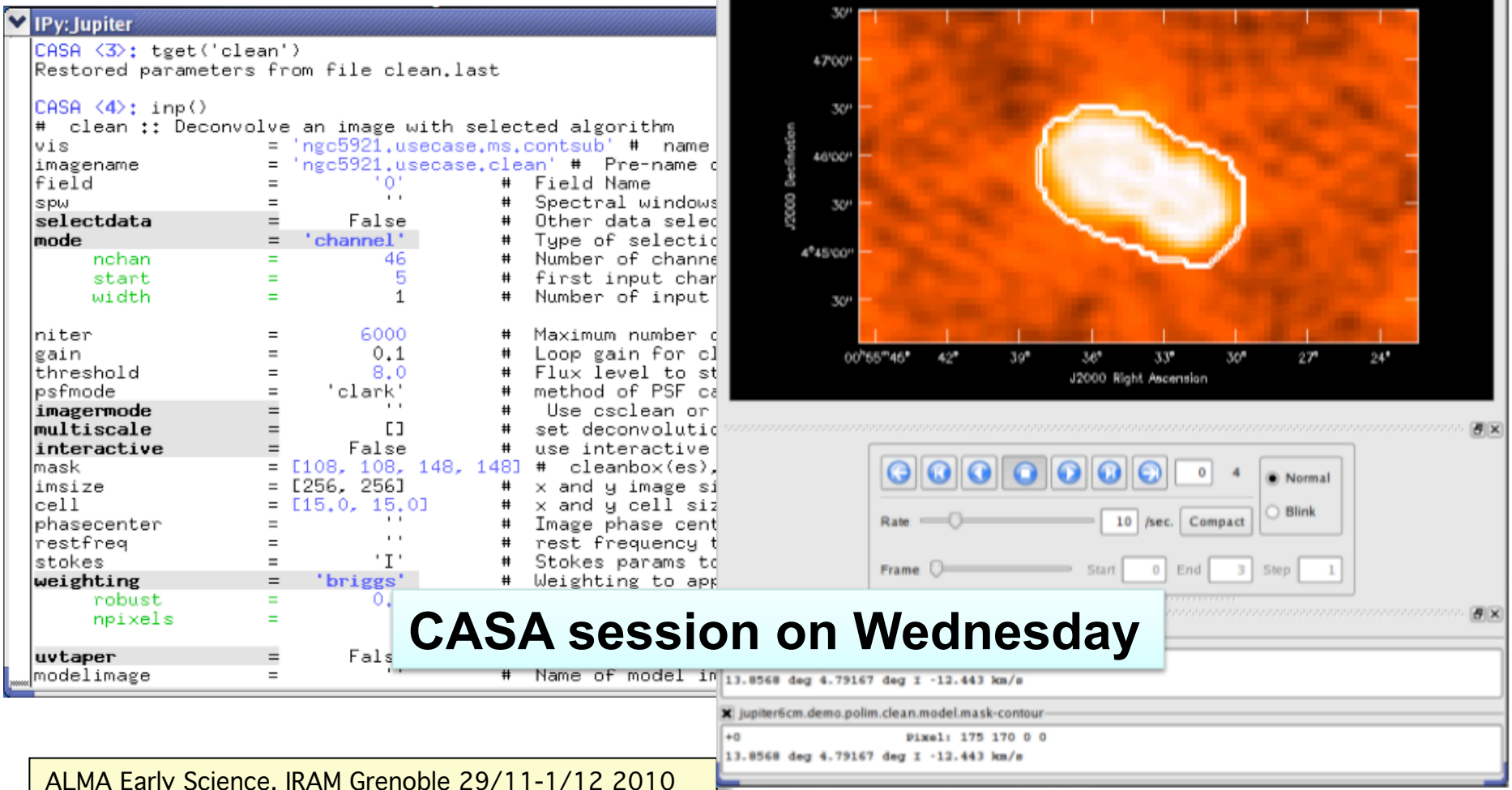
The ALMA offline reduction pack



CASA session on Wednesday

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Simulating the data

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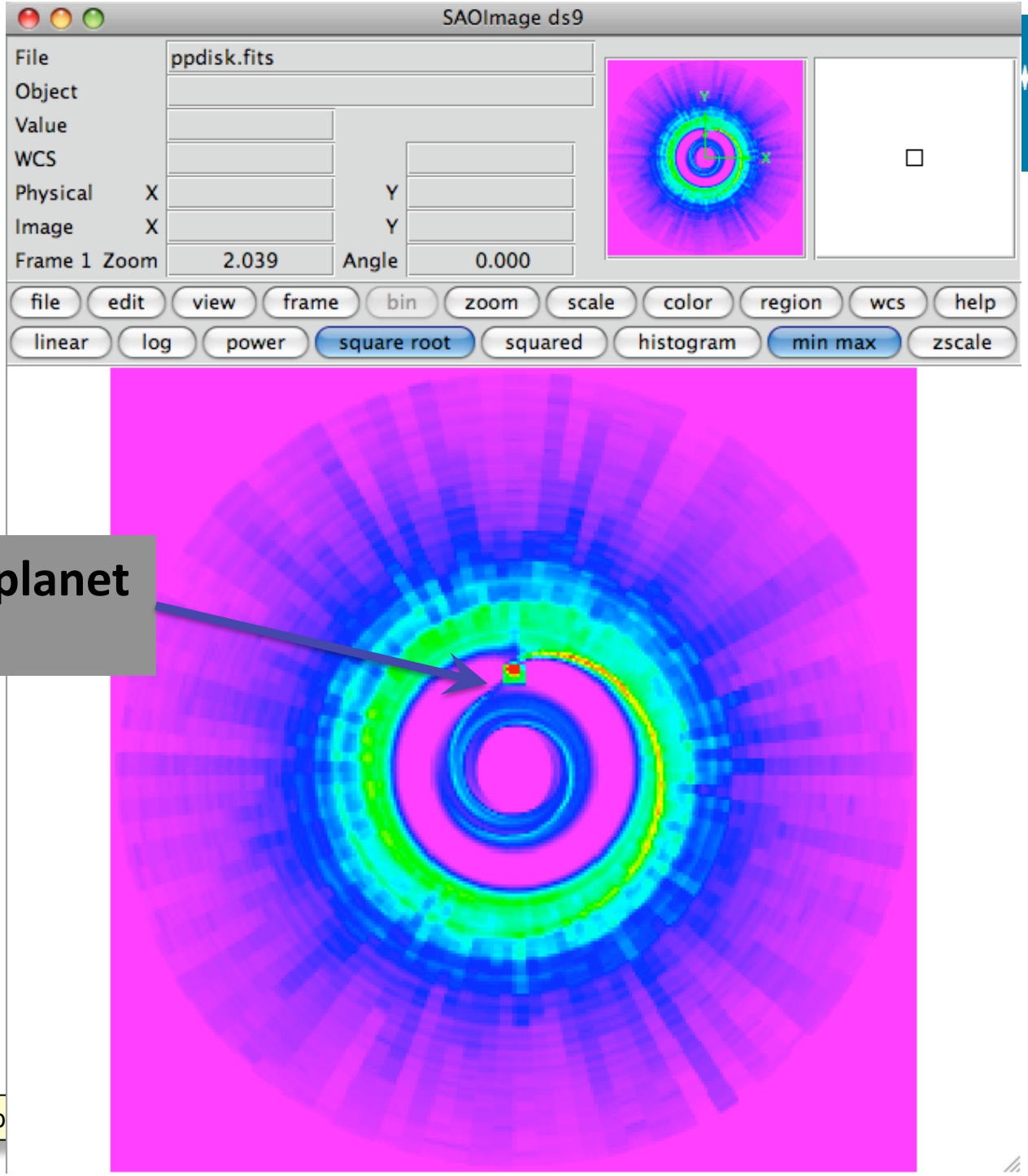

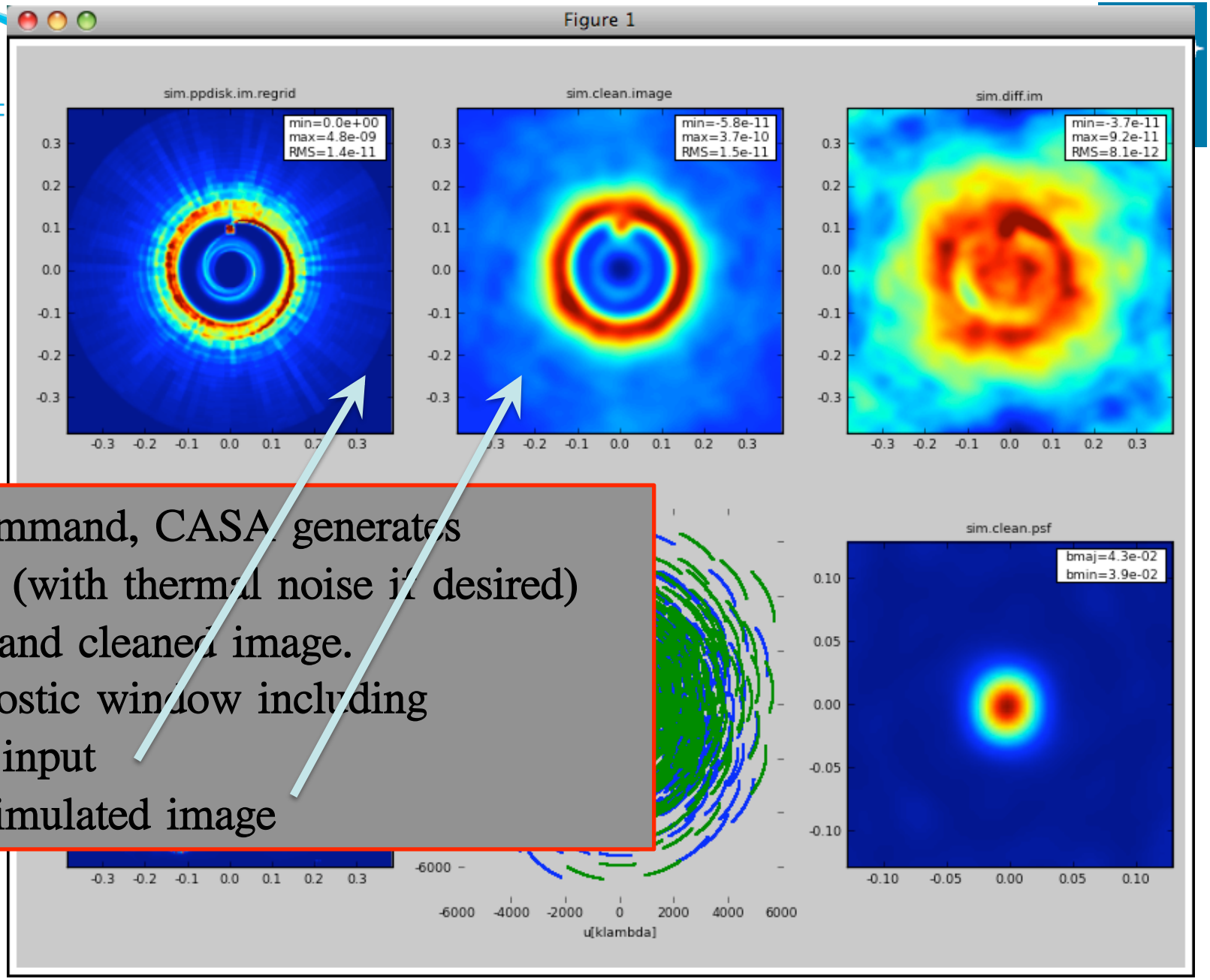

In one command, CASA generates

- uv data (with thermal noise if desired)
- a dirty and cleaned image.
- a diagnostic window including
  - your input
  - the simulated image

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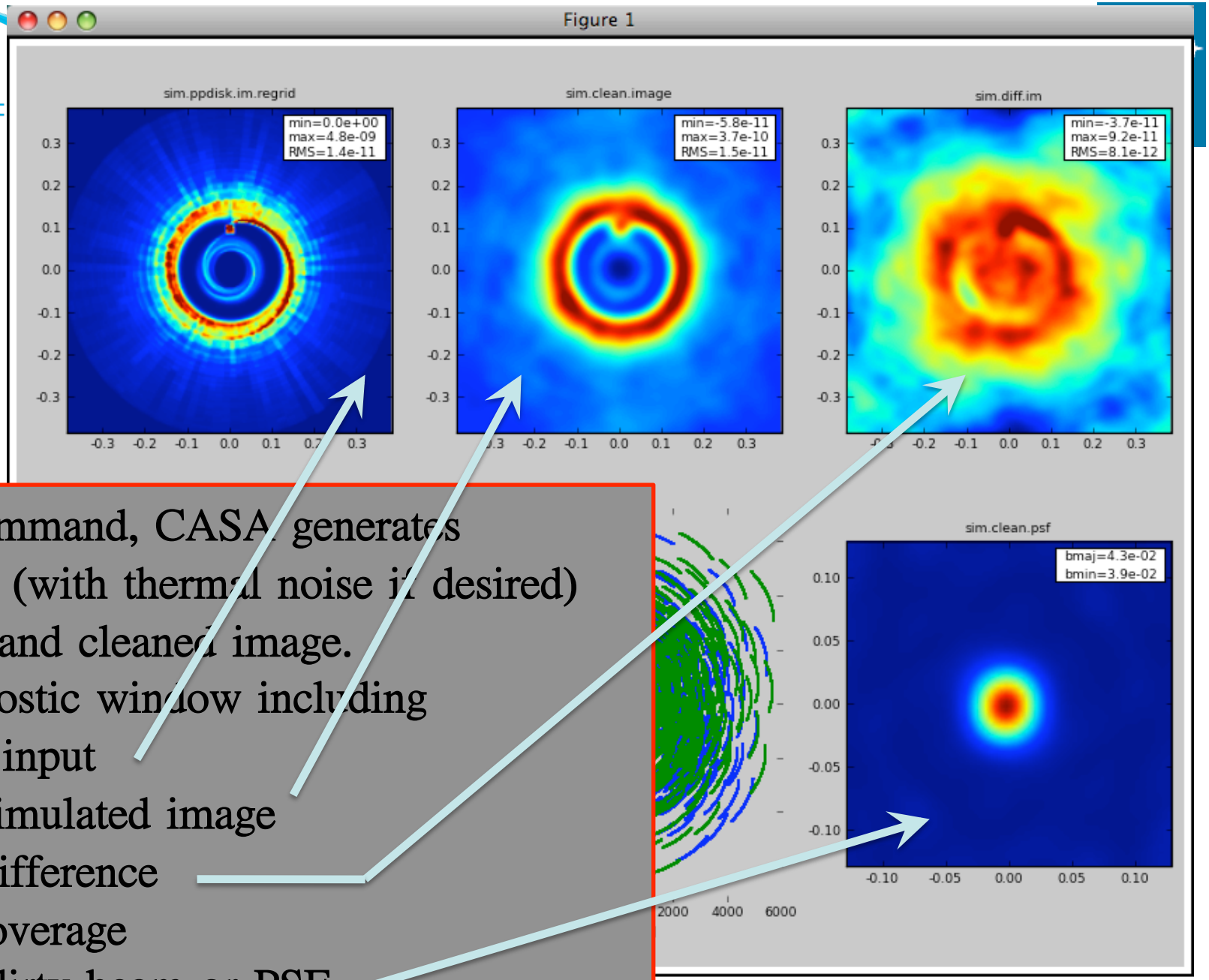

In one command, CASA generates

- uv data (with thermal noise if desired)
- a dirty and cleaned image.
- a diagnostic window including
  - your input
  - the simulated image
  - the difference
  - uv coverage
  - and dirty beam or PSF

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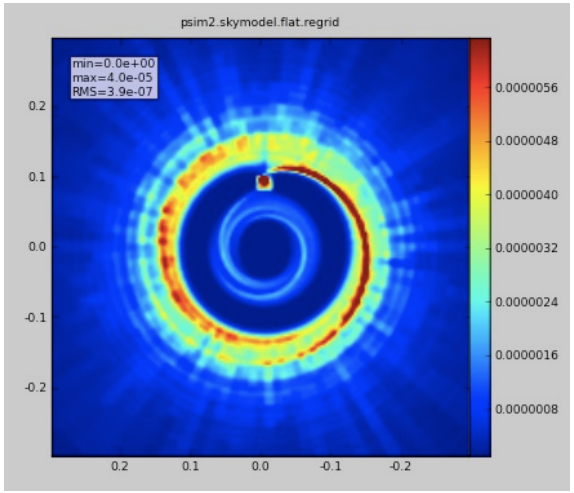
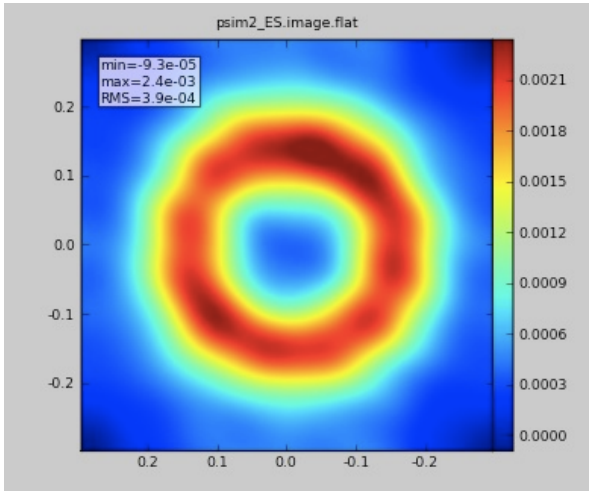
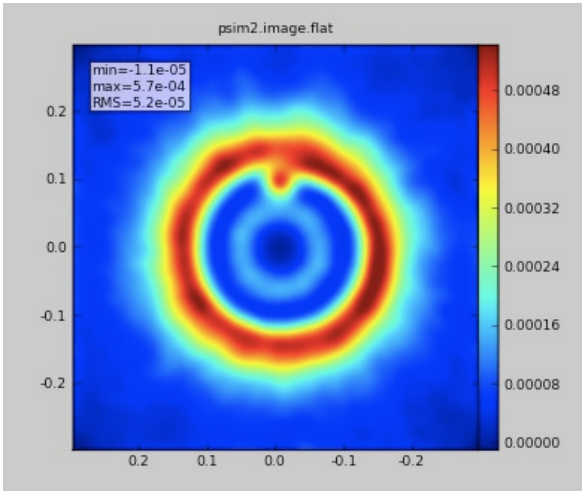
Proto-planetary disk (band 9)







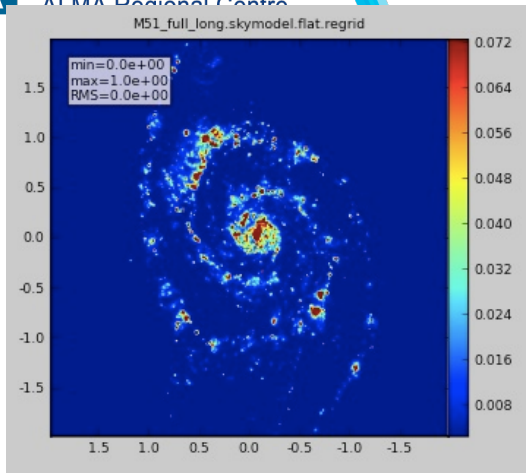
Skymodel

Early Science (30 mins)

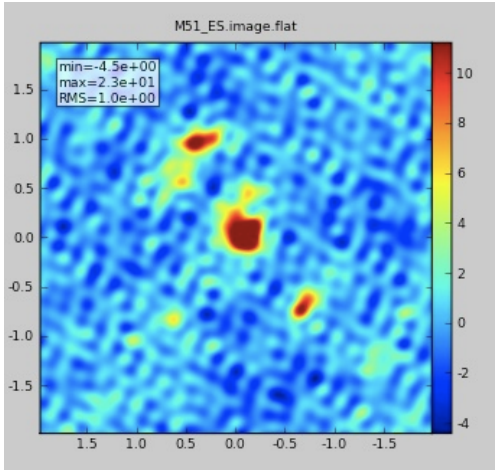
Full Array (10 mins)

E. Van Kampen

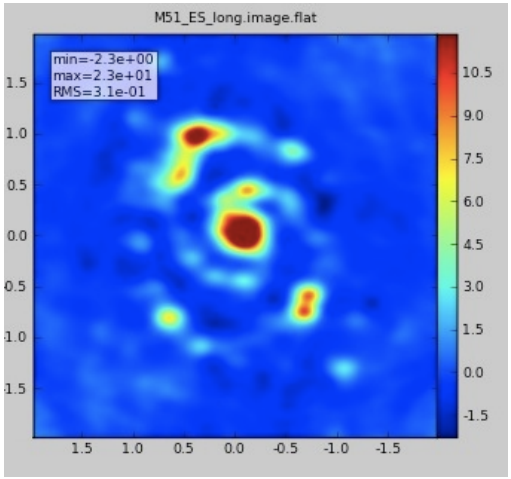
M51-type galaxy (band 9)



Skymodel

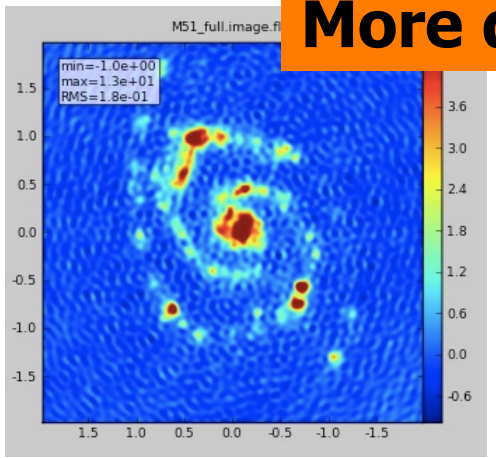


ES (30 min)

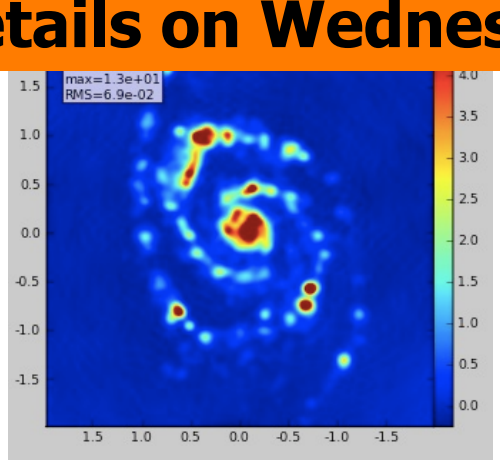


ES (4h)

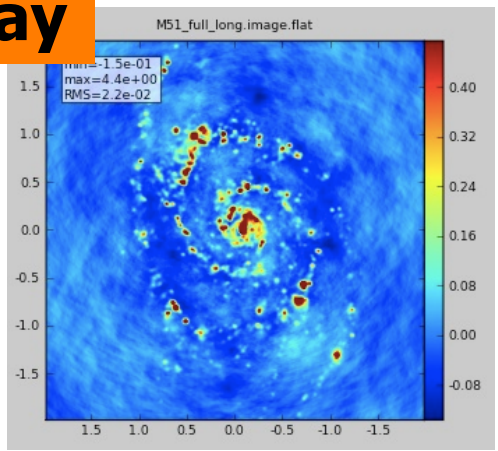
More details on Wednesday



Full 2 km array (30 min)



Full 2 km array (4h)



Full 6 km array (4h)

The European ARC

A Guide to the European ARC

Guide to the European ALMA Regional Centre

Version 26 October 2010

The European ARC

- Core functions
  - Scientific support:
  - Proposal & observation preparation
  - user support
  - Archive Operations:
  - host a copy, data delivery
  - Astronomer on duty at OSF
  - Science community activity
  - User support:
  - f2f help

ESO: ARC Department

ARC nodes

- Non-core functions
  - Data reduction
  - Advanced pipeline
  - Extended archive support
  - Support for special projects
  - Science community activity:
  - training, schools, workshops

ARC nodes

ALMA Early 11-1/12 2010

ALMA simulators

ESO ARC + nodes

EUROPEAN ARC
ALMA Regional Centre

The role of the central node (@ ESO)

- Participation to Commissioning Science Verification (2years)
- Support the European users from proposal preparations to data delivery through the helpdesk
- Validation of the Scheduling Blocks
- Help in the technical assessment of the proposals
- Provide help to the proposal handling team
- Host and maintain a complete mirror of the ALMA archive
- Delivered pipelined, calibrated data
- Provide duties at the OSF during observations
- Manage the ARC nodes

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The ESO ARC staff

7 astronomers

5 scientists

ARC Astronomers:
Scientific user support (proposal, SB, OSF duties, technical assessment, proposal handling)
Help in managing the nodes

ARC scientists
Helpdesk, SW testing and implementation, SW feedback, archive queries

Archive operations
(system administration, data delivery, database)

5 contractors

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The role of the ARC nodes

- **Provide one to one user support (proposal, SBs preparation, data reduction, archive research)**
- **Participate in the helpdesk**
- Scientific community development
- New software and techniques
- Advanced data reduction

- Public relations and outreach

The ARC nodes: staff

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- **Bonn-Bochum-Cologne,** Germany (F. Bertoldi)
- *Current staff:* **Bonn:** 2 staff astronomers (part-time 25-50%), 1 postdoc, IT support; **Cologne**: 4 staff astronomers (part time 5-10%); **Bochum**: 3 staff astronomers (part time 30%) + 2 COFUND Fellows

- **Bologna,** Italy, (J. Brand)
- *Current staff:* 5 staff astronomers (part-time), 3 postdocs, 1 technician, IT support, 1 staff position advertised + 1 COFUND Fellow

- **Onsala,** Denmark, Sweden, Finland (J. Conway)
- *Current staff:* 1 staff astronomers (at 30%), 1 astronomer + 1 SW engineer, maybe 1 more position

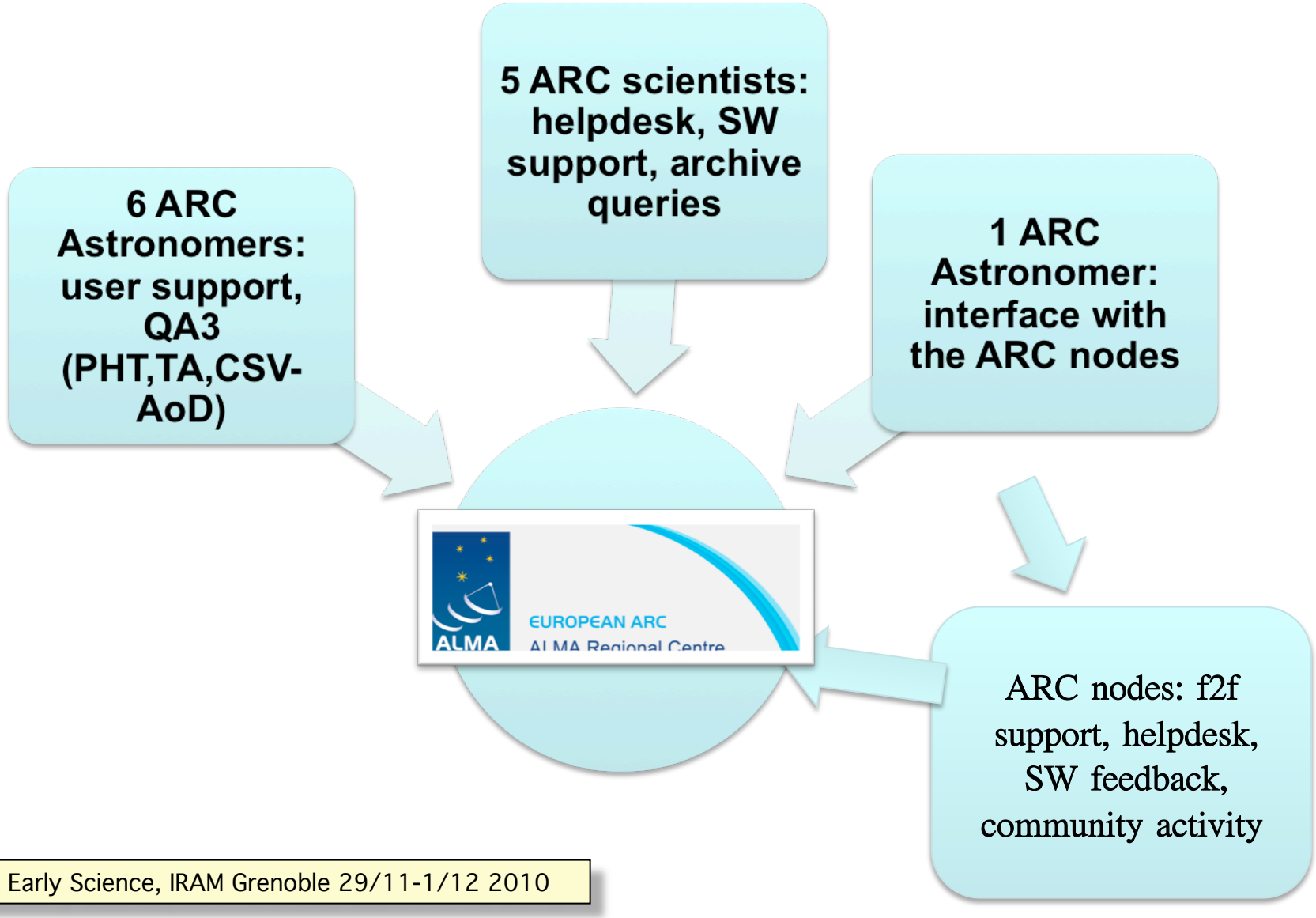
- **IRAM,** Grenoble, France, Spain, Germany (F. Gueth)
- *Current staff:* 5 IRAM staff share the task ALMA/PdB support (10-50 %) 1 postdoc, + 3 SW engineer + 1 COFUND Fellows

- **Leiden,** The Netherlands, (M. Hogerheijde)
- *Current staff:* 2 staff astronomers (part-time) + 2 postdocs, + 1 COFUND Fellow

- **Manchester,** United Kingdom (T. Muxlow)
- *Current staff:* 4 staff astronomers (10-50%), 1 staff 100%, + 1 COFUND Fellow

- **Ondřejov,** Czech Republic (M. Karlický)
- *Current staff:* 4 staff astronomers (10-50%), 1 SW engineer, IT support, 2 postdoc

User support and helpdesk



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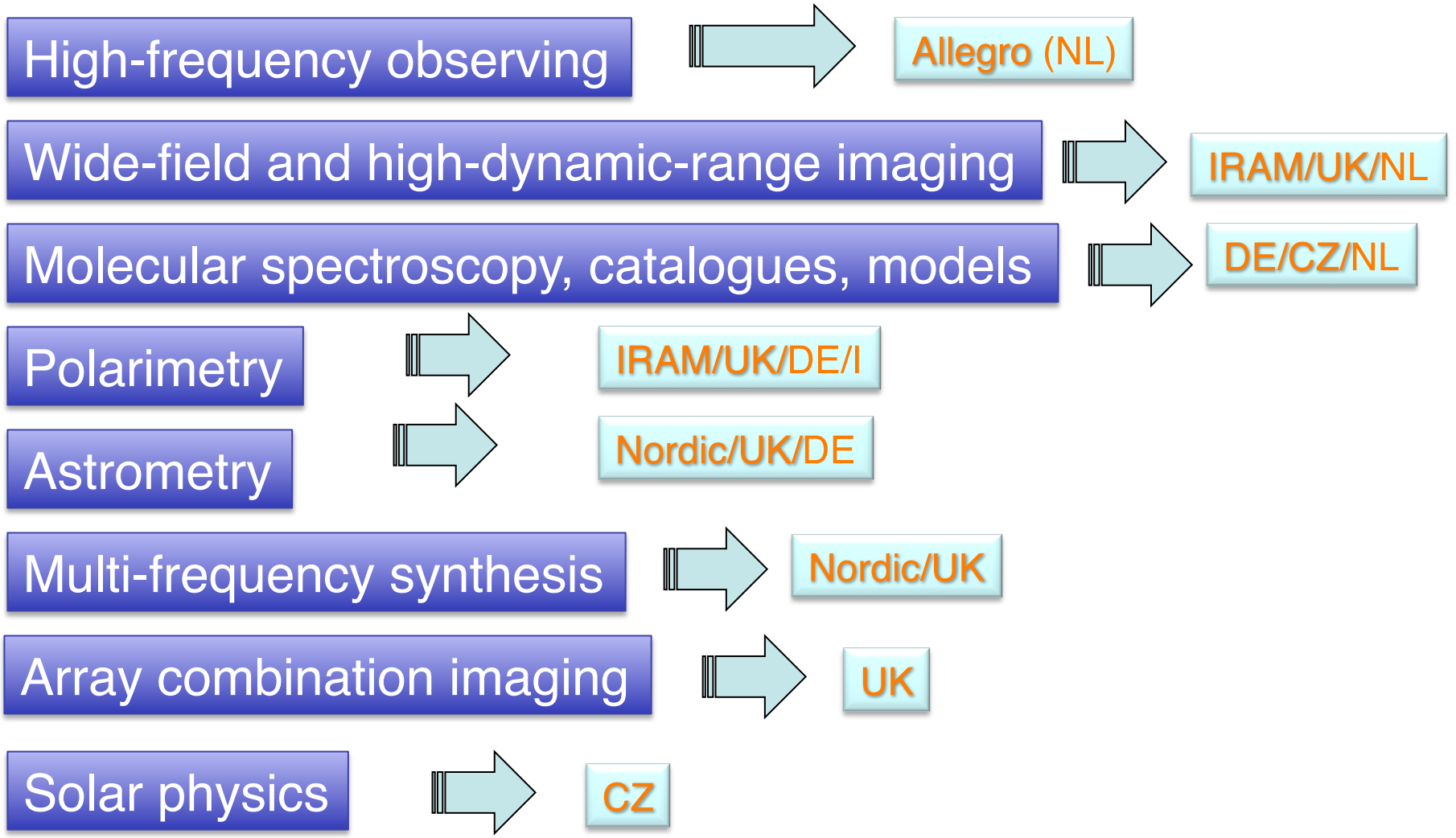
Helpdesk @ the EU ARC



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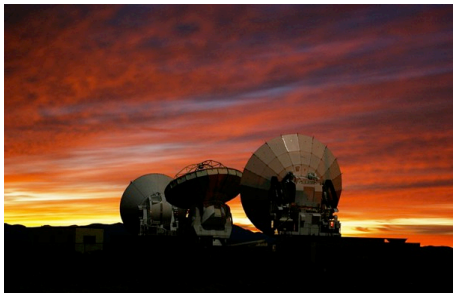
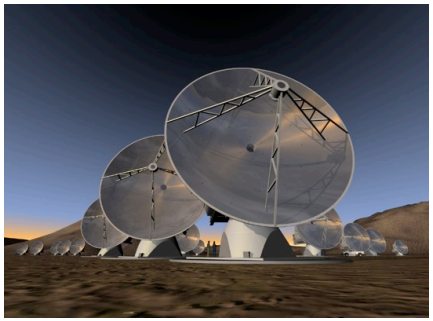
Current Timeline

- **Start of CSV (Commissioning and Science Verification): Jan 2010** (3 antennas at the AOS)
- **ESDP (Early Science Decision Point): Nov 2010 (Board meeting)**
  - Mirror Archives in place
  - ALMA User Portal activated
  - ALMA Helpdesk activated

by the Call for Proposals (Q1 2011)



- Deadline for proposals (2011 Q2)
  - PRC review procedure initiated
- Deadline for PRC final ranking (Autumn 2011)
  - Preparation of SBs
- **Start Early Science: Autumn 2011**
  - Take and deliver data



- **Inauguration: September 2012**
  - More than 50 fully equipped antennas
- **Baseline ALMA Construction Complete 2013**

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Early Science Operations

- Start Science Operations before the ALMA construction finishes
- Minimum requirements for Early Science
- Goals for Early Science
- Early Science Operations: two cycles (0 & 1)
  - Cycle 0: 8 months scheduling period
  - Cycle 1: One year scheduling period
  - Time shared with commissioning. At most 33% of available time will be dedicated to ES observations.

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Questions?